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551.5:061.4

The Royal Meteorological Society Exhibition 1978

When the British Meteorological Society, later to become the Royal Meteorological Society, was founded in 1850 much of its work was concerned with the setting up of a basic network of meteorological observations over the United Kingdom. During the century and a quarter of the Society's existence, the science of meteorology has steadily developed and the Society's work has extended to include the stimulation of research and application over the fields of meteorology, climatology and oceanography and the encouragement and organization of meteorological education for both amateurs and professionals.

To mark the move of the Society's Headquarters to James Glaisher House in Bracknell an exhibition was arranged in Bracknell College from 14 to 17 July 1978. Nearly 80 different institutions drawn from universities, government departments and industry provided contributions, so that the current scope of the Society's interest was well represented. Her Majesty The Queen, Patron of the Society, graciously consented to open the exhibition at noon on Friday 14 July. After an extensive tour of the displays Her Majesty visited the Society's Headquarters where she was entertained to lunch before her visit to Meteorological Office Headquarters.

With no less than 14 different displays, some in the entrance hall and the remainder in the main halls, the Meteorological Office was well represented in the exhibition. On entering, the eye of the visitor was immediately caught by the Meteorological Office Radar Research Laboratory display. This consisted of two colour-television monitors, one showing rainfall intensity as observed by an integrated network of radars and the other infra-red radiances from geostationary and orbiting satellites; these illustrated the development and movement of rain and cloud areas. In the main body of the exhibition two neighbouring displays showed working demonstrations of the Mk 3 radiosonde and of 'AUTOMET', the automatic weather station based on a micro-computer. Another display showed a simple laboratory apparatus for observing wave motions in a liquid in a rotating annular tank, with walls maintained at different temperatures; this wave motion is analogous to that of the atmosphere. Apart from working equipment there were several display panels describing various aspects of the work of the Office; these included alternative approaches to long-range forecasting, a description of a rain-gauge network assessment and rationalization exercise and an account of how the Meteorological Office helps to provide the agricultural industry with operational warning systems for pests and diseases.

The impact of the Meteorological Office displays was enhanced by the uniform format of the display panels. These have dimensions of approximately 1·5 metres by 1 metre with the backboard colour washed in an appropriate pale colour. On top of each board was a blue upstand with the words 'Meteorological Office' in white, and individual spot-lighting was provided for each display. These panels and suitable stands may be made available to outstations wishing to arrange small exhibitions of their own.

This short account would not be complete without a word of praise for the Meteorological Office Cartographic Section, which produced the display panels. The enthusiasm and hard work of the Cartographers ensured the success of the Office's contribution to the Exhibition.

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Visit of Her Majesty The Queen to the Meteorological Office, 14 July 1978

On the afternoon of 14 July 1978 Her Majesty The Queen visited the Meteorological Office during the course of a visit to Bracknell. Her Majesty was accompanied by the Lord Lieutenant of Berkshire, Colonel The Honourable Gordon Palmer, and Her Lady-in-Waiting, The Honourable Mary Morrison.

On arrival at the Meteorological Office Her Majesty was greeted by Dr B. J. Mason, the Director-General who presented Dr K. H. Stewart, the Director of Research, and members of the Senior Directorate. The Director-General took the opportunity of showing Her Majesty photographs taken of the occasion of her previous visit on 25 June 1962 shortly after the Headquarters Building had been opened.

Dr Mason conducted Her Majesty to the Central Forecasting Office (CFO) where Mr D. E. Jones, the Assistant Director in charge, described the work of CFO and presented several members of the staff who described their work to Her Majesty. Mr K. F. Sylvester, Chairman of the Institution of Professional Civil Servants Branch Council and representing the Staff Side, was presented to Her Majesty at the end of the visit to CFO.

Her Majesty also visited the COSMOS Computing Laboratory where the Director-General presented Mr G. A. Howkins, the Assistant Director in charge of Data Processing, who described the work of the Laboratory. Individual members of the staff described their work to Her Majesty, who was also given a demonstration of chart-plotting equipment.

On her departure from the Office Her Majesty signed a specially illuminated page of the Visitors' Book which was subsequently put on display at popular request.

During the visit many members of the staff and their families took the opportunity to see Her Majesty from vantage points in the car park, lobbies and corridors.

Subsequent to the visit, the Director-General has received a letter from the Private Secretary to Her Majesty expressing Her Majesty's thanks for 'an extremely interesting afternoon' and commenting on the excellent explanations given by members of the staff. Her Majesty was 'touched by the charming reception given to her'.

551.513.1

Concerning general circulation models

by A. Gilchrist

(Deputy Director (Dynamical Research), Meteorological Office, Bracknell)

The paper that follows is based on a lecture at the summer meeting of the Royal Meteorological Society, July 1976.

Numerical models of the general circulation are among the most powerful tools available for studying the large-scale behaviour of the atmosphere. They have many applications, actual and potential: for understanding features of the atmospheric circulation, for studying pronounced abnormalities of weather or changes in climate, for investigating the impact of natural or man-made pollution, for weather forecasting and the assessment of atmospheric predictability, for determining optimum observational systems, and so on. They should be of interest not only to those who create and develop them but to everyone concerned about how the atmosphere works, and in particular to the wide cross-section of the meteorological community whose researches stand to benefit from the application of such models to particular problems. To foster a wider, but critical and discerning appreciation of their potential is a worthwhile aim which it is the intention of this article to further. It seems to me that the most useful approach is to discuss certain features of general circulation models and results which sometimes cause perplexity, misunderstanding or even concern, and thereby allay doubts which may be ill founded.

To begin with, consider the global mean-sea-level pressure fields for January and July simulated by the Meteorological Office general circulation model (Figures 1 and 2). They have been obtained in the usual way; that is to say, the global general circulation model was presented with an isothermal, motionless atmosphere of total mass and (by implication) gaseous constitution similar to those of the real atmosphere. The surface temperatures of the oceans and the radiation parameters were set to their climatological mean values for the appropriate month, and the model was then integrated forward numerically until 100 days had been simulated. During this time the motions created by the model took on many of the observed characteristics of the atmosphere. The charts shown were obtained by averaging the mean-sea-level pressure distributions for the last 40 days of the experiments. Details of the model can be found in published papers, e.g. Corby *et al.* (1972, 1977). Comparing the model simulations with the climatological pressure distributions for January and July (Figures 3 and 4) it is evident that the model is capable of reproducing the main observed systems. We may note for example the subtropical anticyclones, the Aleutian and Icelandic lows, and the low-pressure belt around the Antarctic continent, whose positions and seasonal change of intensity are correctly indicated. The change-over from the Siberian anticyclone and the north-east monsoon of January to the low-pressure monsoon trough of July is realistic.

It is, however, not my purpose here to discuss at length the successes or failures of the model. It is, as I have indicated, to try to answer nagging questions which arise when diagrams like these are shown. Perhaps the first matter to clarify is the significance to be attached to the simulated surface pressure maps. There may well be a feeling that reasonably correct simulations of the pressure field might nevertheless be associated with poor values of the bulk properties of the flow, the fluxes and the energy transformations, which are the quantities usually discussed in papers on the general circulation. Our experience indicates otherwise. The surface pressure distribution arises as a result of many complex processes going on within the model, on the divergence of the wind, on the mutual

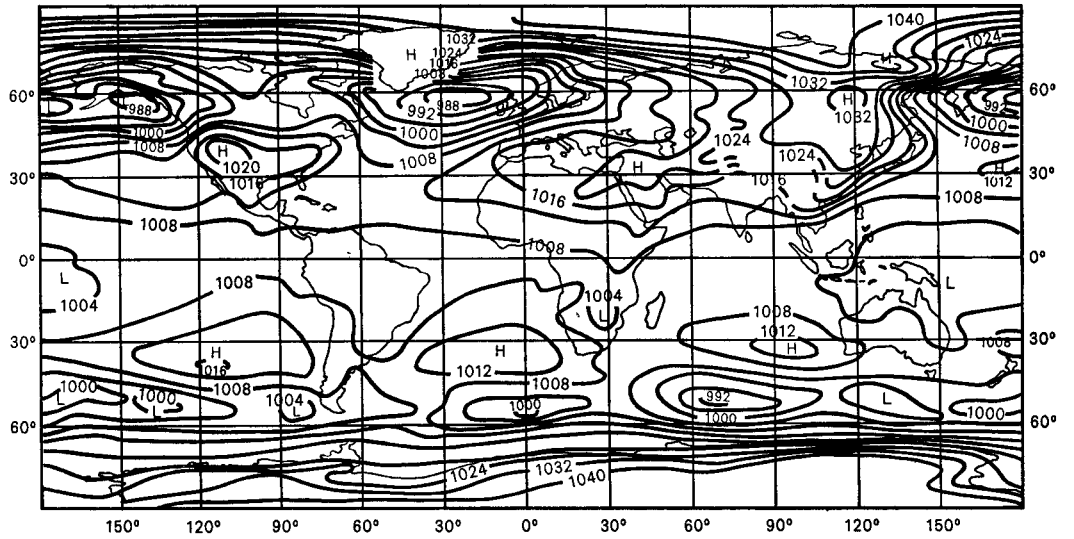

Figure 1. Time-mean chart of pressure at mean sea level from days 61–100 of the January integration. Isobars are at 4 mb intervals.

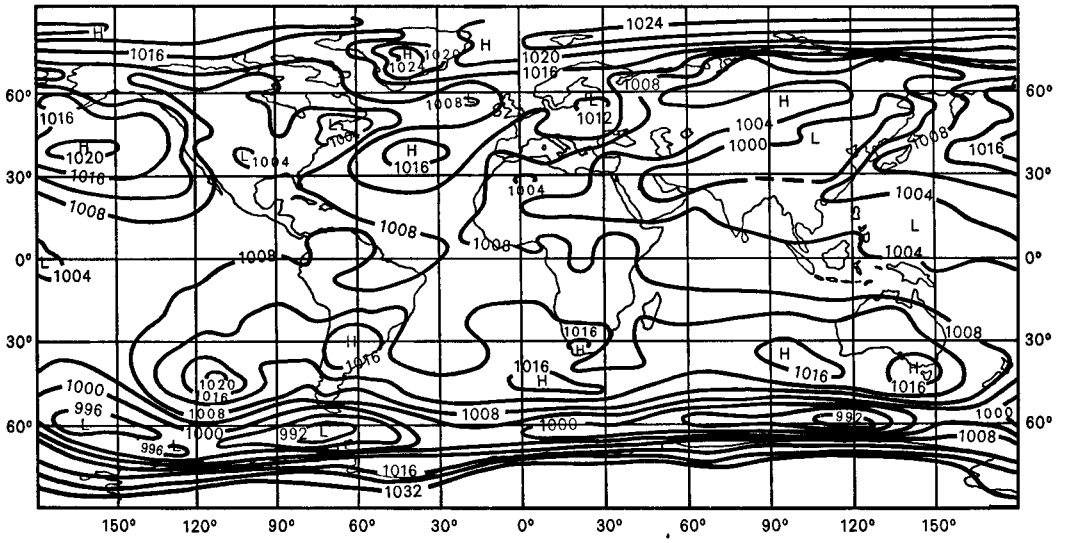

Figure 2. Time-mean chart of pressure at mean sea level from days 61–100 of the July integration. Isobars are at 4 mb intervals.

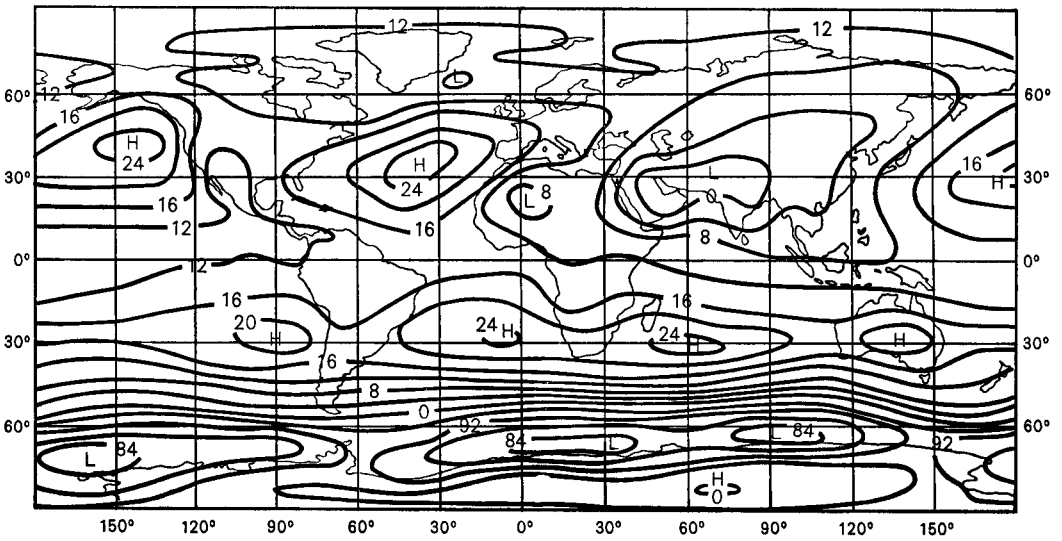

Figure 3. Observed average pressure at mean sea level, January. Isobars are at 4 mb intervals.

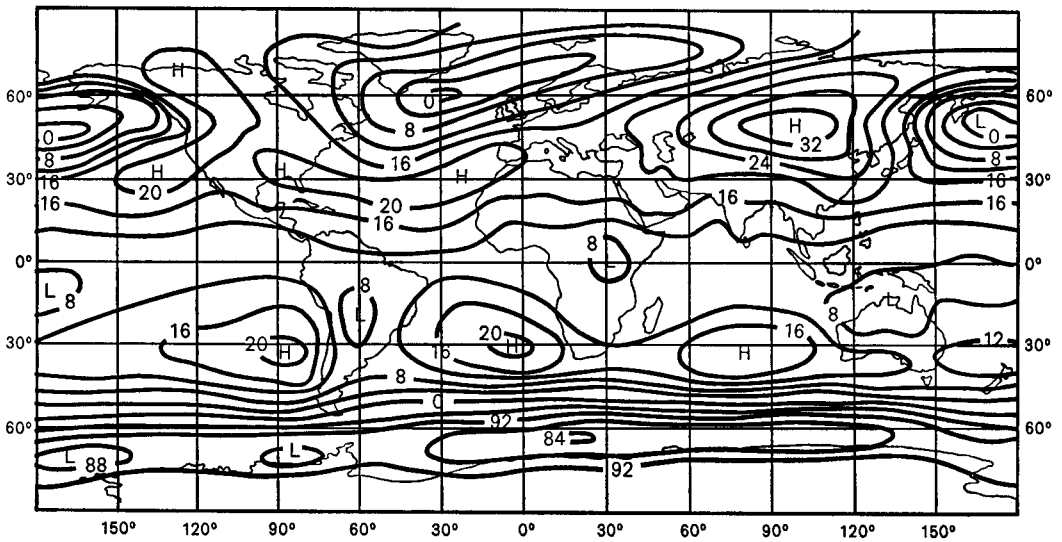

Figure 4. Observed average pressure at mean sea level, July. Isobars are at 4 mb intervals.

adaptation of wind and mass fields, on the ability to reproduce realistic depressions and so on. The surface pressure effectively integrates all these, and is sensitive to errors in them. At least as it has appeared in developing our general circulation model, it is not likely that one will find a poor simulation which does not betray its shortcomings somehow in the surface pressure fields; equally, if the surface pressure field is realistic both in its time-mean values and in its day-to-day evolutions, the bulk properties of the flow are most probably realistic also. On the other hand, many integrated quantities seem to be comparatively insensitive to major defects in the model.

It may also be noted that the surface pressure is the meteorological variable about which we probably have the greatest knowledge both as regards its distribution in space and its variability in time. It is therefore less susceptible than other variables to sampling or observational errors, which can easily complicate the process of comparing model results against actuality. In choosing indicators of the quality of climatic simulations, I doubt if one could do better than give primacy of place to the mean-sea-level pressure field, backed up if possible by a measure of its day-to-day variability.

Following many precedents, I have already compared the model simulations with the long-term climatology. One may well ask if this is appropriate. Certainly it is wrong to consider the climatology as the 'correct' answer, to which the simulations should conform in detail. The model result represents an average of only 40 days, whereas the climatology has been determined from some thousands of days, and there are good statistical reasons for expecting means over such diverse periods to differ. One can indeed assert that if the model's result is closely similar to the climatology, it is unlikely that it simulates the atmosphere realistically on a day-to-day basis. It is obviously more satisfactory to regard the model simulation as representing a single month and then seek an answer to the question: 'Does it differ significantly from the population of observed monthly mean distributions?'. For this, the variability of the monthly mean values is taken into account by calculating 'Student's-t', the distribution of which is shown in Figures 5 and 6 for the area of the northern hemisphere for which mean-sea-level pressure charts were available in the Meteorological Office. [Note: Before calculating 't', a small correction 'ϵ' was added to all model pressure values to make the model and atmospheric masses the same over the area of calculation, it having been noted that the total mass in the model was sightly deficient.] Values of 't' greater than 2 may be expected by chance on about 5 per cent of occasions, but values as large as 3 should be very uncommon. High values associated with mountains may be ignored, since they depend on the method of reduction to sea level and could be largely removed by a less simple-minded method. The figures indicate that the most significant errors in the simulation do not in general coincide with the largest deviations from climatology. In January, north-west Canada has pressures that are consistently low and the area near the pole is too anticyclonic. In July the standardized deviations are larger and more widespread; in particular the deficiency of pressure in the subtropics and the excess in polar regions constitute substantial errors.

It must now be pointed out that in deriving these results, a very important factor has been ignored, namely, that the atmosphere is subject to a variety of effects which differ from one year to another and indeed from one part of a month to another but which have been kept constant in the model. Thus in the model the temperatures of the surface of the oceans and (at least by implication) the cloudiness are not allowed to change. Since one must expect major anomalies of the atmospheric circulation to be associated with anomalies of ocean temperatures and cloudiness, the spread of possible model simulations obtained by starting from different initial situations at the beginning of the 40-day averaging period should be less than that for the real atmosphere. Consequently, the 't'-values as calculated above tend to present an unduly favourable impression of the model results. There is, however, no way of separating out that part of the variability of the atmosphere which is produced by the effects that are kept fixed in the model. The natural way of pursuing this topic is

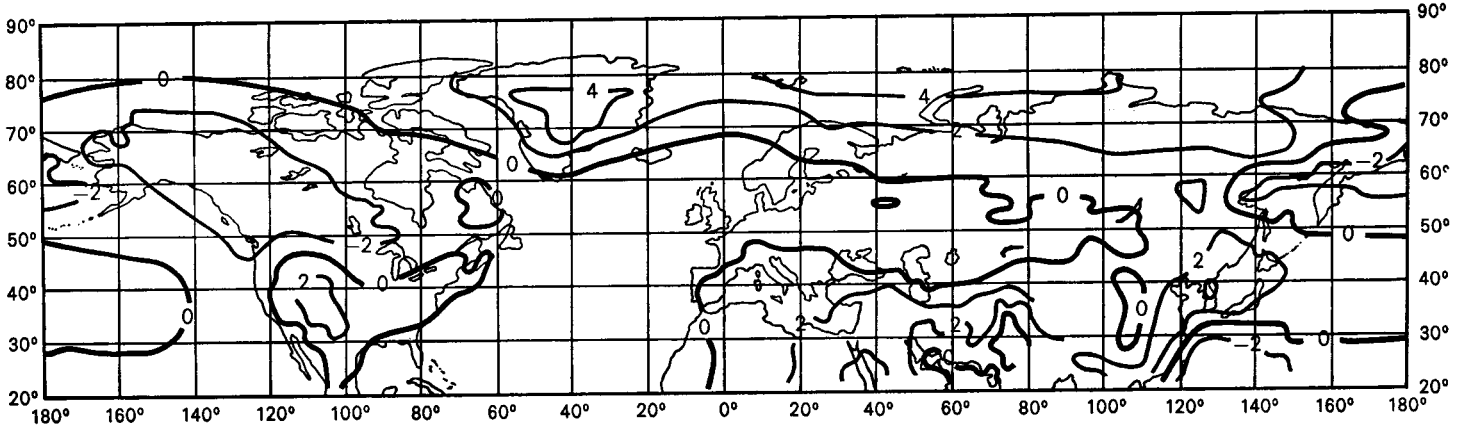

Figure 5. 'Student's-t' for January integration.

$$t = \frac{\text{January integration—observed average pressure at m.s.l.} + \epsilon}{\text{observed standard deviation of January pressures}}.$$

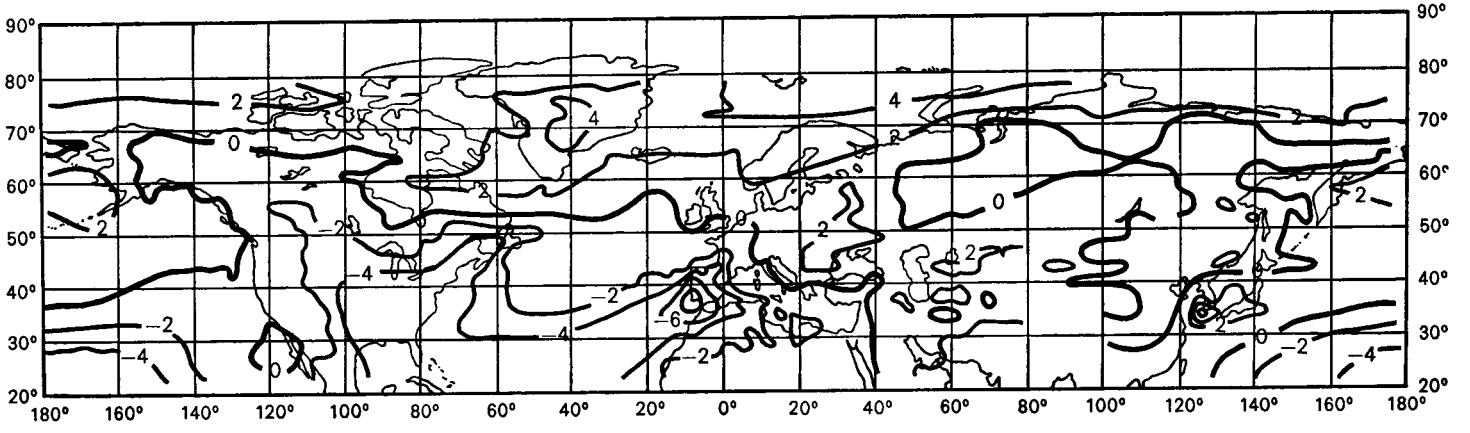

Figure 6. 'Student's-t' for July integration.

$$t = \frac{\text{July integration—observed average pressure at m.s.l.} + \epsilon}{\text{observed standard deviation of July pressures}}.$$

to assess the changes in the model simulations induced by progressively relaxing the constraints that have been imposed; primarily this involves making cloud amount a function of the model variables, and incorporating an ocean model so that the interaction between ocean and atmosphere is properly represented. The process is one that has only just begun; it will be the major preoccupation of general circulation groups during the next few years.

There is one aspect of the interaction of the atmosphere and the ocean which I would like to pursue here since it has caused some misunderstanding. It is the question of the importance and significance to be attached to the use of fixed climatological temperatures for the oceans during the simulations. Thus, replying to a letter from Sawyer (1974) which quoted general circulation model results as demonstrating that a postulated geomagnetic influence on the atmosphere did not appear to be necessary to explain observed 500 mb heights, Dr King of the Appleton Laboratory has written (1974) '. . . the results were obtained using a model which incorporates as a necessary boundary condition, values of the observed sea-surface temperature which were held constant throughout the calculations. The temperature map used by Gilchrist *et al.* is such that the 6 °C isotherm moves 21° towards the north (from 45°N to 66°N) while crossing the Atlantic from America to Europe and 18° northwards while crossing the Pacific from Asia to America. It is obviously not possible to use the results of calculations which incorporate such boundary conditions to decide whether the Earth's magnetic field or any other external phenomenon influences the circulation of the atmosphere.' In a broad philosophical sense Dr King is no doubt correct. The point is, presumably, that it is conceivable that the oceans carry the influence of the geomagnetic field, so that when a numerical integration is carried out using fixed ocean temperatures, this influence is fed back into the atmosphere. I refrain from comment on the inherent plausibility or implausibility of the hypothesis that the atmosphere responds to the geomagnetic field but I am concerned to look at the notion, essential if what Dr King says has any validity, that the sea surface temperatures imply the atmospheric circulation so that if they are fixed at their climatological values, any reasonable model can be expected to reproduce the climatology of the atmosphere as a whole.

We must be clear in the first place why assumptions about the temperatures of the ocean surface are made. The oceans are vast store-houses of heat. The motions within them constitute one of the prime methods of transferring heat from low to middle and high latitudes, where as a result of exchange at the surface it is released into the atmosphere. Because cooling of the surface layers causes the cool surface water to descend and be replaced by warmer water from below, cooling, if continued, spreads through a deeper and deeper layer. Recollecting that the heat equivalent of the whole of the overlying atmosphere is the same as that of the top $2\frac{1}{2}$ metres of the ocean, and that the annual cooling cycle can extend down to 100 metres and beyond, it is obvious that the oceans are such a powerful source of heat that they cannot be ignored in any attempt to simulate a realistic atmospheric climatology. The release of heat from the oceans to the atmosphere must be included in a reasonably realistic way. Because cooling can proceed to considerable depths, the sea surface temperature tends at many times of the year to be fairly conservative, and the assumption of quasi-constant values for integrations of about a month is not too unrealistic.

However, it is not so much the temperatures themselves but rather the difference between them and the temperatures of the continental surfaces, that are of major importance in influencing the atmosphere. Consider for example, the surface temperatures in the model at 61·5°N and 58·5°N for the January simulation shown in Figure 7. Dr King suggested that the geomagnetic field influenced the atmosphere most markedly at about these latitudes. The sea surface temperatures (denoted □) are fixed, while the model determines for itself the temperature of sea-ice and land points, though the positions of the former are also fixed. It is evident that at these latitudes relatively few temperatures

are provided for the model and that they in themselves give little hint of the true atmospheric variation in the zonal direction. Nevertheless, the sea points are of crucial importance, because they represent the locations where very cold air streaming off the cold continents extracts heat from the ocean down to considerable depths. Vertical instability spreads the heat through the atmosphere, and conditions favourable for cyclonic development are produced. This is the prime mechanism by which the 500 mb troughs are formed, and therefore it is unlikely that these climatological troughs will ever

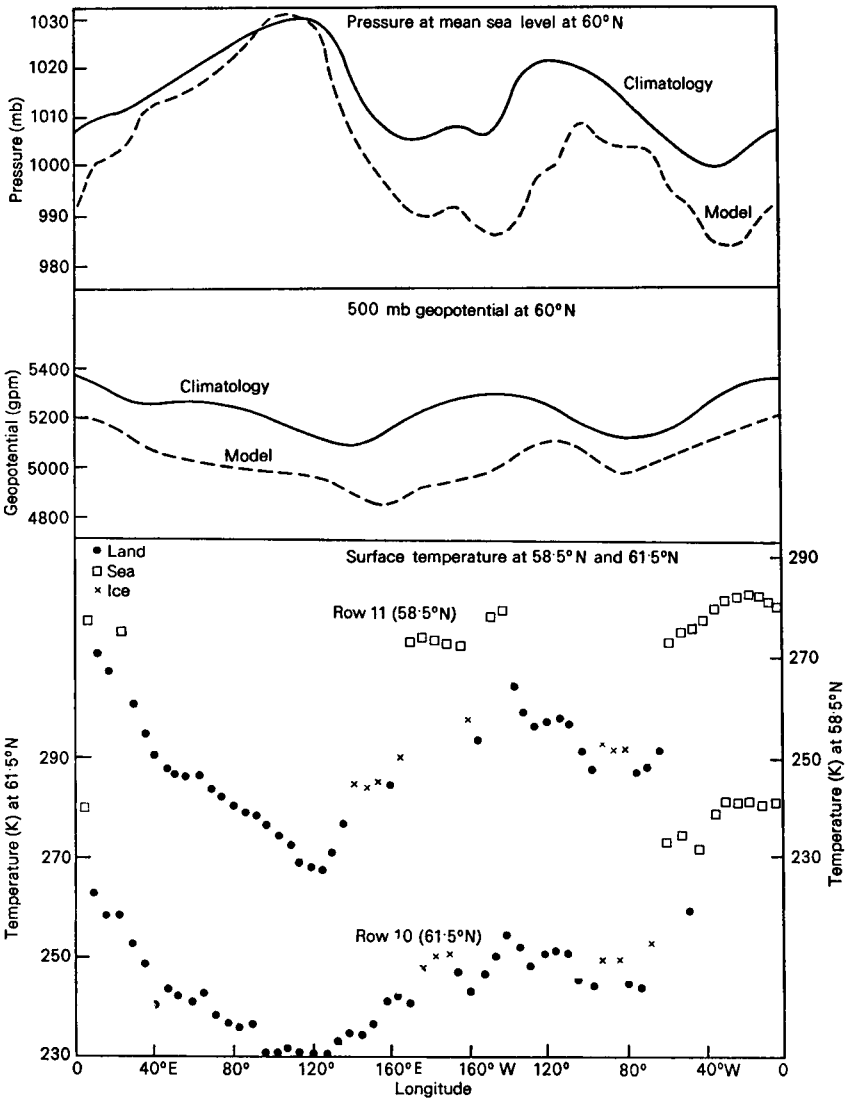

Figure 7. Average pressure at mean sea level and 500 mb geopotential for the January integration as observed at 60°N, and the temperatures of the earth's surface at grid points near 60°N in the integration. The type of surface is indicated as: □—sea, whose temperature is prescribed; ●—land, ×—sea ice, whose temperatures are determined by the model.

stray very far from the position of the boundary between land and sea or ice and sea. In Figure 8 the similar diagram for July is displayed. For this month, the number of points with prescribed temperatures is larger, but there is little indication that their information content about the longitudinal variation of atmospheric parameters is substantially greater. The model does not reproduce the features of the atmospheric climatology to the same degree as in January, but this result has to be viewed in the light of the considerations about testing the quality of simulations dealt with earlier.

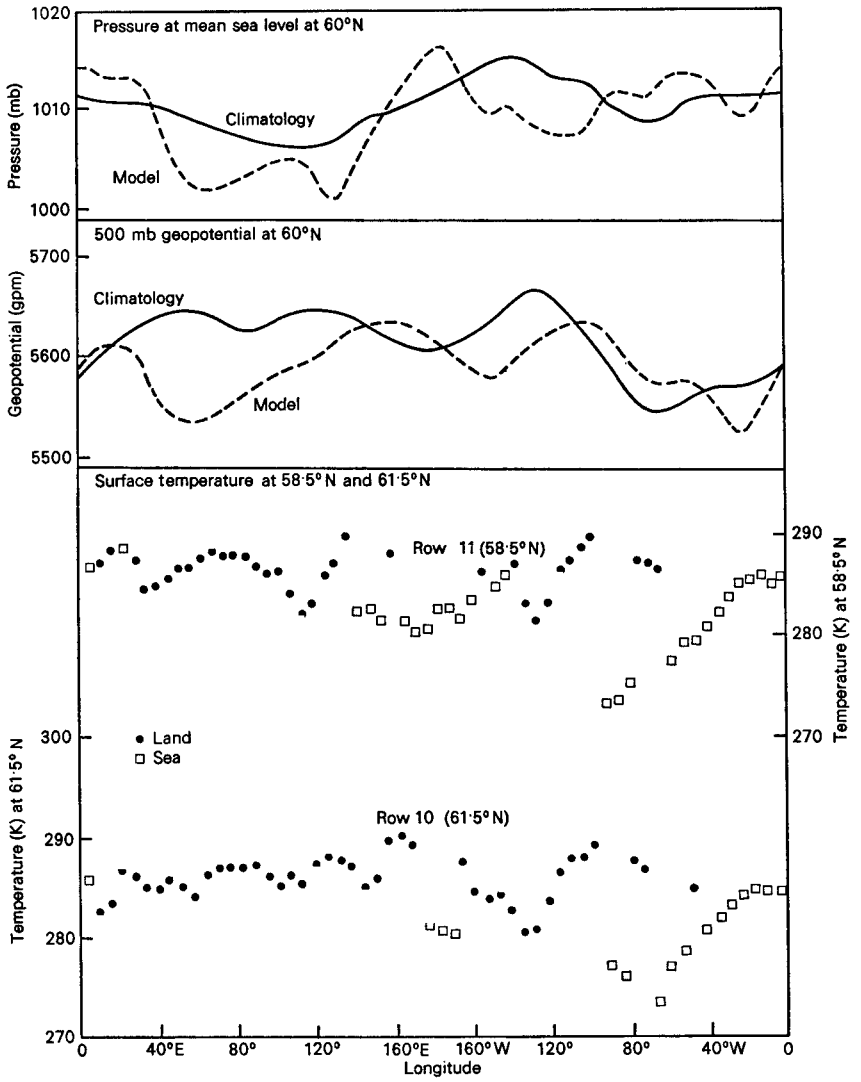

Figure 8. Average pressure at mean sea level and 500 mb geopotential for the July integration as observed at 60°N, and the temperatures of the earth's surface at grid points near 60°N in the integration. The type of surface indication is explained below Figure 7.

Another way of looking at the influence of the sea temperatures is to consider the change in surface pressure between January and July relative to the change in temperature. Thus, in Figure 9 the surface pressures and sea surface temperatures are shown for 30°W and 140°W, two longitudes chosen because they lie for the most part over oceans. It is clear from them that the changes in the atmosphere between summer and winter bear no simple relation to the change in ocean temperatures, which have on the whole a simple form, with winter cooling and summer warming of a few degrees Centigrade. It is also evident that, contrary to what would be expected if the sea surface temperatures were themselves the dominating factor, pressure and temperature are positively correlated. Again, it is the temperature over the sea relative to that over land that is important; in summer, though the sea is warmer than in winter, it is relatively cold, and vice versa in winter.

To sum up, it is clearly true that for a purely atmospheric model to obtain a realistic representation of the general circulation, it is essential that the temperature of the surface of the ocean be prescribed to be at least close to the observed values, but to suggest that the prescription of the ocean temperature ensures a realistic atmospheric simulation is, at best, a gross over-simplification.

Let us turn now to consider another matter which often seems to be misunderstood. It is the question of how far models are 'optimized' to the present climate, since a high degree of optimization* would imply that they are unsuitable for studying changes of climate. The possibility of optimization arises because processes which take place in the atmosphere on scales smaller than the resolution of the model mesh have to be 'parametrized' in terms of the large-scale variables. A parametrization is by its nature a statistical representation which can only be correct by-and-large and on average, since it is clear that the subgrid-scale processes being represented are not uniquely defined by the large-scale explicit atmospheric situation. Further, parametrization often involves quantities which, because they attempt a description of events averaged over a large area (a typical grid square area is about 10^{11} m^2), cannot readily be measured, or which at the present time have not been measured at a sufficiently large number of points over the globe to provide all the information required in a global model. The modeller therefore has to choose values for a number of 'disposable constants' in his model and the difficult question which arises is how far is it scientifically legitimate for him to choose these to obtain the best agreement between the model and the atmosphere as it is now observed.

I shall not attempt to deal with the question philosophically or in generality, but simply content myself with discussing the parameters and how they were obtained in the Meteorological Office general circulation model, some of whose results have been seen.

Perhaps, however, the first point to be made is that results for both January and July, at the extremes of the annual cycle, have been shown. The only difference in the two cases was that the ocean temperatures and the radiation constants were changed. It is obvious that the differences between the winter and summer months are very large, especially in the northern hemisphere where the juxtaposition of oceans and continental land masses plays a dominant role in determining the overall circulation. The difference indeed is greater than the departure of any particular month from the normal for at least the last millenium. It may be claimed with some justification that if a parametrization contributes substantially to a model whose simulations are realistic at both extremes of the annual cycle, it is more than just a device that happens to work; it probably represents the physical situation reasonably well.

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* By 'optimization' is meant the deliberate setting of adjustable parameters to values chosen so as to make the result of a computation as near to reality as possible; such parameters occur in semi-empirical or statistical formulations of physical processes as opposed to formulations derived from fundamental scientific laws.

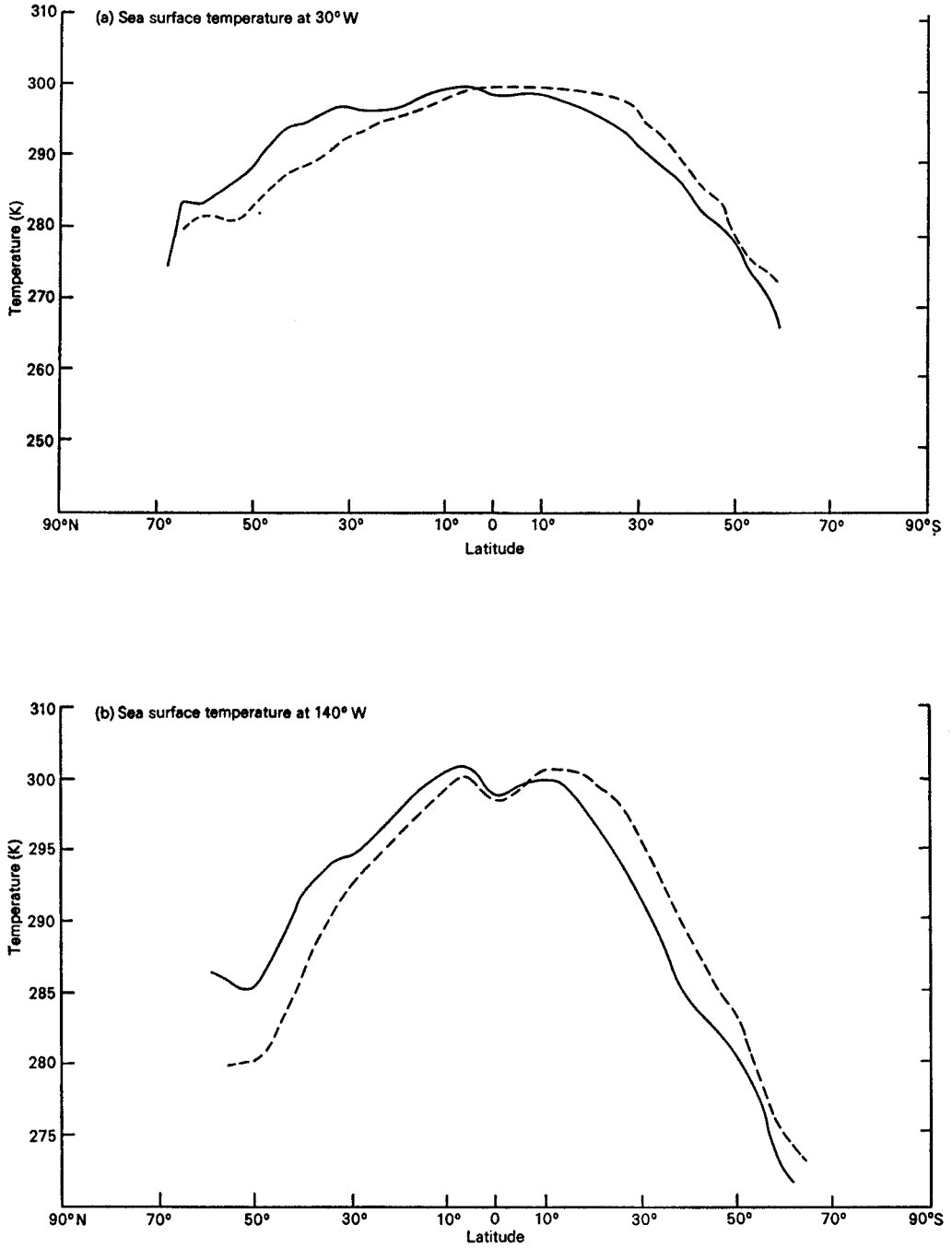
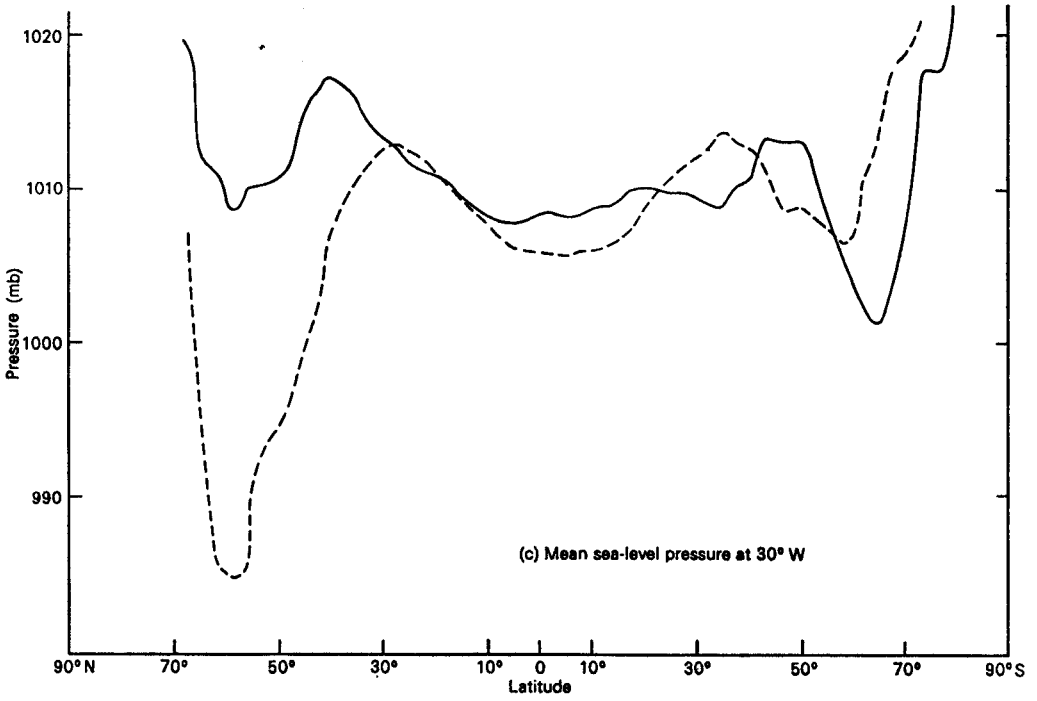


Figure 9. Prescribed sea surface temperature and average pressure at mean sea level in the model simulation for January and July at 30°W and 140°W.
——— July – – – January



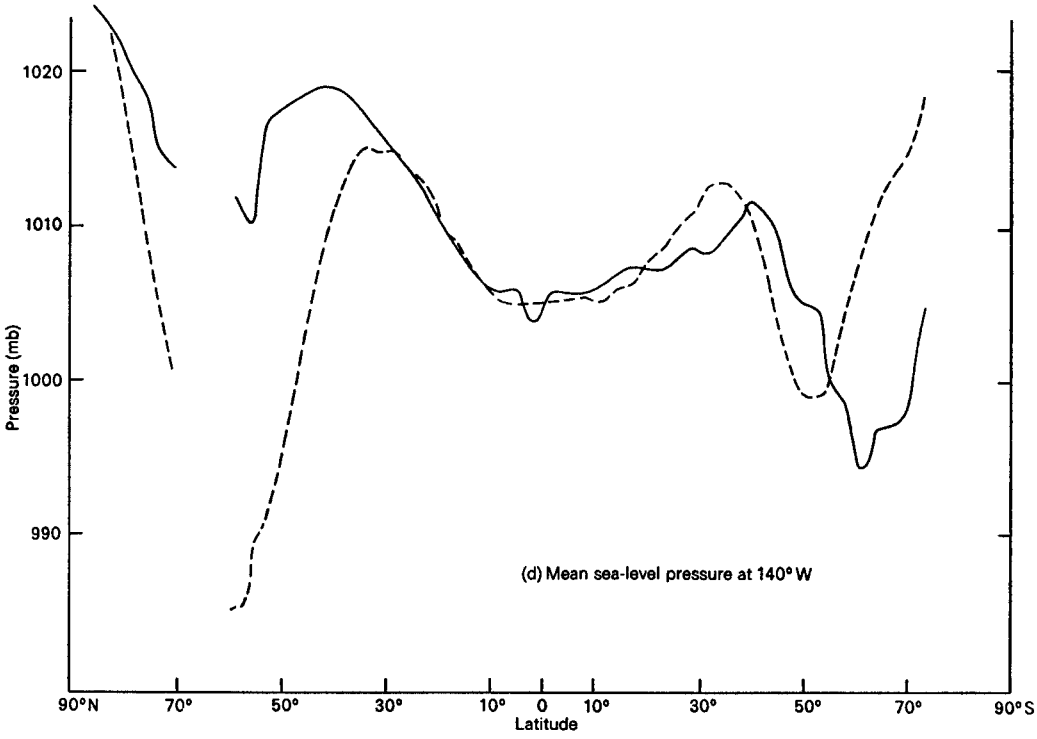


Figure 9—*continued*

Consider now the processes which have to parametrized, and which therefore are susceptible to 'optimization'. They can be thought of as four in number, namely (a) the exchange of heat, water vapour and momentum between the atmosphere and the underlying surface, (b) the transfer of heat, water vapour and possibly momentum vertically through the atmosphere by convective processes, (c) the transfer of energy from the large-scale motions represented explicitly to the subgrid-scale implicit motions and the interaction between the two regimes, and (d) radiative processes. The possibility of optimization arises in all of these processes, but I shall dismiss the first three rather rapidly, for I can see no real evidence that the representations have been 'tuned' in a manner which would limit the use of the model in studying the motions of the earth's atmosphere. (The atmospheres of other planets may be another matter.) In support of this stance, there are listed in Table I the main 'disposable constants' and the methods used to find appropriate values for them.

Table I. *The main 'disposable parameters' in the Meteorological Office general circulation model, and basis for choice of values*

1. Surface exchanges	(a) Surface drag parameters land/sea; stable/unstable.	Taken from published values. See papers to 1967 GARP study conference.
	(b) A: accounts for enhanced heat and moisture exchange coefficients in unstable conditions.	First estimate based on published experimental data; later halved.
2. Convective exchange	(a) 'Rate' coefficient k (b) Excess buoyancy (ϵ^T, ϵ^q) (c) Detrainment (a, b)	Single-column experiments
3. Subgrid-scale dissipation	(a) 'Rate' coefficient K	Empirical

The parameters in the surface exchange formulation have been for the most part chosen directly from published curves, which themselves were based on combined theoretical and observational considerations. Because only four different situations are allowed for, namely whether the surface is land or sea, and whether the atmosphere is stable or unstable, this was particularly easy. An additional constant is required to account for the observation that, with increasing instability, the exchange coefficients for heat and moisture increase relative to that for momentum. The first formulation of this effect, for which quantitative assessment from observations is still rather uncertain, appeared to give too much heat exchange and evaporation from tropical oceans. In a re-formulation the constant was halved. This is a change made in the light of experience, but it is hardly optimization in the sense considered here because it involves the direct comparison with observations of a single process which is not well defined either theoretically or observationally. Potentially undesirable changes presumably involve arguments such as 'the coefficient in the formulation for surface exchanges was altered because certain dynamical features were simulated better as a result'.

The parametrization of subgrid-scale vertical convection involves constants (or pairs of constants) in the definitions of three quantities: the rate at which convection stabilizes an initial vertical instability, the excess buoyancy over its environment of a parcel which tests whether or not vertical instability exists, and the proportion of an ascending mass of air which 'detrains' into a layer through which it is passing. They were determined from single column experiments in which, starting from an initially unstable ascent, convection was allowed to redistribute heat and water vapour to achieve stability. The constants chosen were one set for which the change took a realistic time (an hour or two) and the intermediate vertical profiles appeared in accord with experience. No changes have been made

Photograph by courtesy of the Royal Meteorological Society

Plate I. Her Majesty The Queen being greeted by Professor J. T. Houghton at the entrance to James Glaisher House (see page 33).

Photograph by courtesy of the Royal Meteorological Society

Plate II. A moment during the presentation of an autographic rain-gauge to Her Majesty.

Photograph by courtesy of the Bracknell News

Photograph by courtesy of the Bracknell News

Plate III. During the visit to the Meteorological Office, Her Majesty is shown the Prestel terminal by Mr J. Parker (top), and is briefed by the medium-range forecaster, Mr M. F. Lee (bottom).

Photograph by courtesy of the Bracknell News

Plate IV. Her Majesty talks to Miss D. J. Phillips, the duty British Isles forecaster (top), and has the computer system explained by the shift manager, Mr E. H. Dixon (bottom) (see page 34).

Plate V. Her Majesty signing the Visitors' Book at the Meteorological Office watched by the Director-General, Dr B. J. Mason (see page 34).

Photograph by courtesy of the Royal Meteorological Society

Plate VI. Her Majesty looks at one of the Meteorological Office exhibits at the Royal Meteorological Society Exhibition (see page 33).

in the constants since the parametrization was inserted in the general circulation model. Unless it were proposed to use the model in circumstances where even the processes of convection on subgrid scales were expected to be substantially different from those now observed, there should be no impediment to the use of this parametrization.

Whereas in the boundary layer and convective parametrizations the emphasis of research is currently on observational and numerical experiments aimed at establishing an accurate physical description of the processes, the interaction of the motions represented explicitly with the subgrid-scale implicit motions lends itself to theoretical treatment. Based upon the premise that the smallest scale explicit motions are linked to even smaller scales by a common turbulence structure it has been possible to treat this aspect with a degree of rigour and elegance. This very circumstance tends perhaps to obscure the reality that at least for general circulation models now available, the representation of this effect performs merely the rather menial task of smoothing the variables in the horizontal. This being the case, it can certainly ruin what is otherwise an excellent simulation, but it can never overcome shortcomings in the physical formulation. In practice, the magnitude of the 'rate coefficient' for determining how much smoothing should be applied is determined empirically by the requirement that these simulations are neither excessively rough nor devoid of meaningful detail. This is optimization of a kind, but not, surely, such as to limit the applicability of the model to climatic change experiments.

The list in Table I is not exhaustive, but it contains the parameters which have a substantial influence on the simulations. A number of others which effect useful but comparatively minor improvements (e.g. those which define the method of finding the surface exchanges when there is evidence of a strong surface inversion) have been omitted since they are of little significance in the present context. A more detailed consideration would be tedious and would add little to the general picture that has been described.

For the simulation of radiative processes, the situation is very different in that the model whose results have been shown employs a definite particularization to the present climate. The form this takes is that the infra-red cooling and the solar heating rates are based upon the zonal mean structure of the observed atmosphere, including observed humidity and cloud amounts. Clouds, which are of the greatest significance in determining the radiation balance of the atmosphere, are therefore included implicitly in such a way that variations in time and longitude are not allowed. Figures 10(a) and (b) show the net cooling rate of the atmosphere for January and July. The assumed cloud has a marked influence for example in creating the maximum cooling at middle and high latitudes at around the 700 mb level in the winter hemisphere. There is a dependence of the infra-red component of the net cooling of T^4, allowing some variation along a line of latitude at a particular pressure level, but since there is no longitudinal dependence on humidity or cloud, the cooling is heavily constrained to remain close to the values shown.

This net atmospheric cooling is offset by radiation absorbed at the earth's surface and later released into the atmosphere. Because of the assumption that the temperatures of the oceanic surface remain constant, the model treats explicitly only that part of the absorption which takes place over land. This depends upon the reflectivities of clouds, and the albedo of the surface as well as upon absorption within the atmosphere. A complete description of the physical processes is very complex, but the model circumvents many of the problems by, in effect, prescribing the amount of solar radiation absorbed at a land surface, as a function of latitude only (the prescription is not complete because it depends upon snow cover which is a model variable, and this has an effect upon the values at high latitudes). The values are shown as mean daily amounts in Figures 11 (a) and (b) for January and July respectively. They have been determined from observations and from estimates of quantities such as the zonal mean surface albedo, and therefore contain minor bumps and variations which

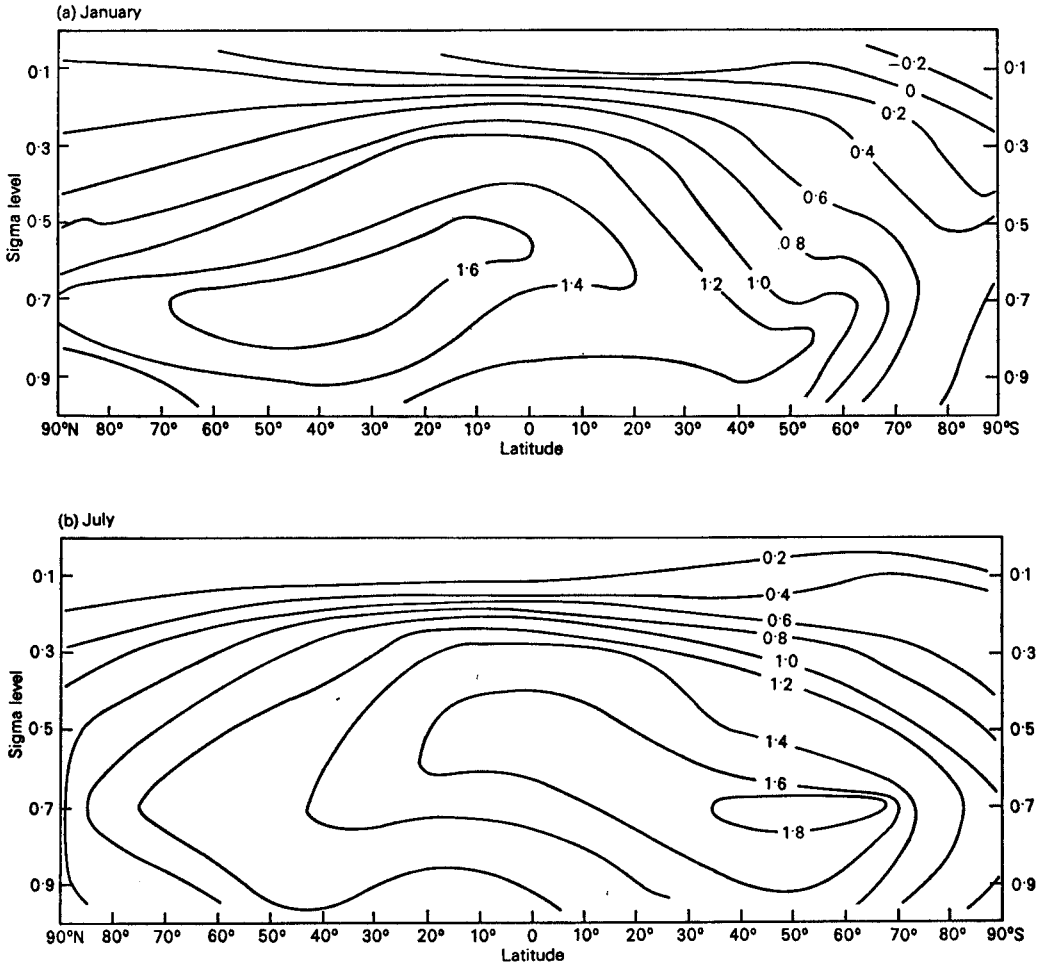


Figure 10. Zonal cross-section of the net cooling rate in kelvins per day in the simulations. The term 'sigma level' derives from the vertical co-ordinate used in the Meteorological Office general circulation model, defined by

$$\sigma = \frac{\text{pressure at point under consideration}}{\text{pressure on the ground vertically below}}.$$

Variations in the height of ground above sea level (i.e. orography) are thus implicitly included in the equations of motion by the use of σ co-ordinates.

probably have little influence on the quality of the model simulations. The effects of clouds and varying surface albedo are the main factors causing the distribution to differ from that of the solar radiation at the top of the atmosphere.

Given the radiation absorbed at the earth's surface, the model determines from its own internal parametrizations how it will be partitioned into radiation back to space, sensible and latent heat exchange with the atmosphere, and storage in the ground. On the assumption that we are dealing with mean daily amounts and that the model has run long enough to be in an equilibrium state, the last of these is probably very small. The zonal mean amount radiated back to space, which depends

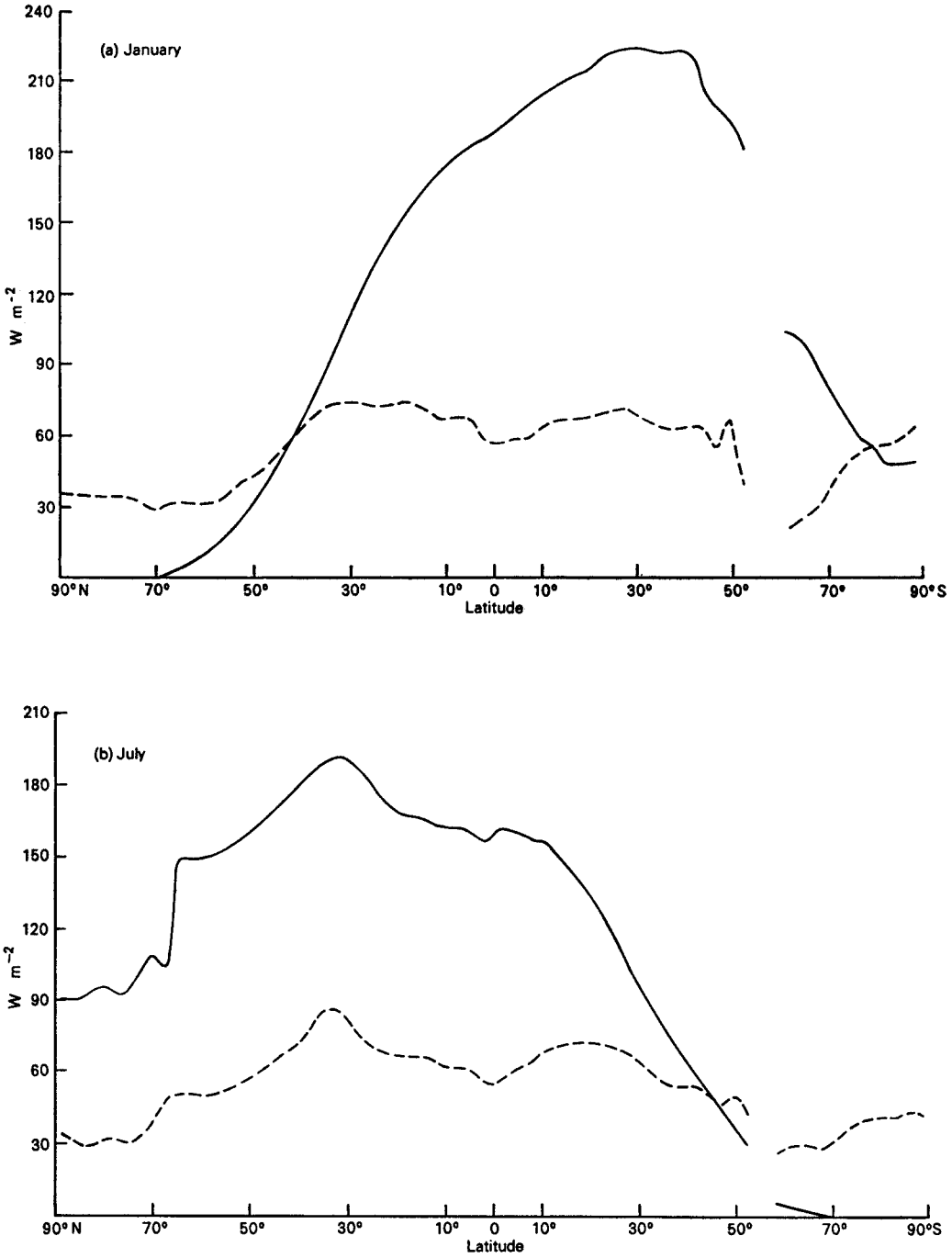


Figure 11. Mean zonal solar absorption by land surfaces in W m^{-2}.
——— Solar radiation reaching the land surface
– – – Infra-red cooling of land surface

on the temperature of the surface carried as a model variable, is shown by the broken line in Figures 11 (a) and (b). The difference in the two radiational quantities is split by the surface exchange parametrization into sensible and latent heat input to the atmosphere. Thus, although some gross features of the radiation at a particular location are largely prescribed, there is still considerable flexibility in the way radiant energy is eventually transmitted to the atmosphere. The resulting spatial variation of surface temperature over land, and sensible and latent heat exchanges have a strong influence on the development of the general circulation.

As well as being clear about the optimization that has been employed, the extent to which it has been deliberately avoided should also be noticed. The radiation scheme is based upon zonal mean values only, and little attempt has been made to account, for example, for the very different radiative conditions likely to exist within air masses at the same latitude over continents and oceans respectively. It is an important aspect of the development of general circulation models to establish how the quality of the simulations depends upon the complication in the parametrizations.

It is evident from the above account that the general circulation model in its present form is simple in many respects, and that, to a degree, this is why it is possible to separate optimized from non-optimized processes. In the period ahead, it will in all probability become more complex as constraints are relaxed and the parametrizations are altered to follow more closely the physical descriptions now being built up from observational evidence. It will at the same time become increasingly difficult to say whether the larger number of disposable parameters are optimized or not. For example, experiments have already been carried out with versions of the model in which the radiation scheme is fully interactive with the humidities and derived cloud. To estimate cloud amounts, formulae relating them to model variables have been determined using as guidance the requirement that the values should be correct for the atmosphere as we now see it. But because of the sporadic nature of clouds and their dependence on subgrid-scale processes, a substantial fraction of the variance is not accounted for and the prescription cannot claim therefore to be very accurate. There is in these circumstances a danger that the formulae chosen will represent an ill-defined mean, which might indeed be unrepresentative in climates not much different from our own. To achieve a cloud prescription of general validity is a problem of great difficulty, to which there may be no fully acceptable solution, but which nevertheless has to be tackled if general circulation models are to be useful in illuminating many of the uncertainties about climate that now concern mankind. Clouds constitute probably the most acute, but certainly not the sole problem of this kind, for similar situations arise with respect to other parametrizations also. The best we can do is surely to make the maximum possible use of the real atmosphere to check numerical simulations, trying to ensure in particular that models are able to reproduce not only average conditions but the most extreme for which ample descriptions exist. Only by achieving acceptable simulations and predictions in a wide range of conditions which can be checked against what happens in the atmosphere can confidence be established in a model's ability to deal with climates beyond those now observed. This will be a long process which will occupy modellers for years to come.

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An eighteenth century rainfall record at Shirburn Castle, Oxfordshire

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Summary

A rainfall record maintained at Shirburn Castle, Oxfordshire, between 1779 and 1795 provides a useful comparison with that of the earliest Oxford rainfall record at the Radcliffe Observatory. The relationship between these two records from 1785 to 1794 is so close to that revealed by modern records at virtually identical sites that the accuracy of the early Shirburn records can be accepted with little doubt.

1. The history of meteorological records at Shirburn Castle

Like many early meteorological records that at Shirburn Castle originated as a consequence of the establishment of a private astronomical observatory. Shirburn Castle, near Watlington, Oxfordshire, was the residence of George Parker, the second Earl of Macclesfield (1697–1764). Elected a Fellow of the Royal Society in 1722, he was President from 1752 until his death. He was a noted astronomer and was one of the principal figures behind the reform of the Calendar in 1752 (Dictionary of National Biography). He was in regular contact with two successive Savilian Professors of Astronomy at Oxford, James Bradley and Thomas Hornsby. About 1739 the Earl built a small private observatory at Shirburn and there is every indication that the building and equipping of the observatory was supervised in collaboration with Bradley who was a frequent visitor at Shirburn (Rigaud, 1832). At this time the facilities available at Oxford for astronomy were certainly inferior to those provided by the Earl at Shirburn (Bell, 1961) and matters were not remedied until Thomas Hornsby, Bradley's successor, was able to obtain funds for the construction of the Radcliffe Observatory (Smith, 1968).

The records of astronomical and meteorological observations at Shirburn between 1739 and 1795 are contained in 28 bound manuscript volumes (Savile MS.) which survive in the Bodleian Library, Oxford. Two of these volumes (Savile MSS. 63 and 64) contain a rainfall record which starts in October 1779 and terminates in October 1795. In addition to rainfall observations the journals containing the principal astronomical observations from 1741 onwards include notes on the weather, principally the state of wind and sky, readings of the barometer and temperatures taken inside and outside the observatory. The meteorological readings are noted for the hours when astronomical observations were made and consequently are mainly during the night. The temperature and barometer readings are almost uninterrupted from 1743 until 1786 and are a most valuable record of daily weather. They supplement and extend Hornsby's Oxford meteorological journal as well as providing confirmation of some notable weather events during this period.

Shirburn Castle is situated some 21 km east-south-east of Oxford (National Grid Reference SU 696959) at an altitude of 107 m. The Observatory was pulled down in the early 19th century when the grounds of the Castle were landscaped (Hassall, 1951) but contemporary accounts (Rigaud, 1832) and an estate plan of about 1800 (Davis, *ca* 1800) describe its size and situation. It was situated 21 m south of the church and 79 m south of the Castle. It was a building measuring about 14 m by 5 m and consisted of three rooms, one of which was fitted as a bedroom. It is not clear whether it was a one or two storied structure, but the plan would suggest that it was on one floor. Presumably since the building was erected as an astronomical observatory the exposure would not have been greatly

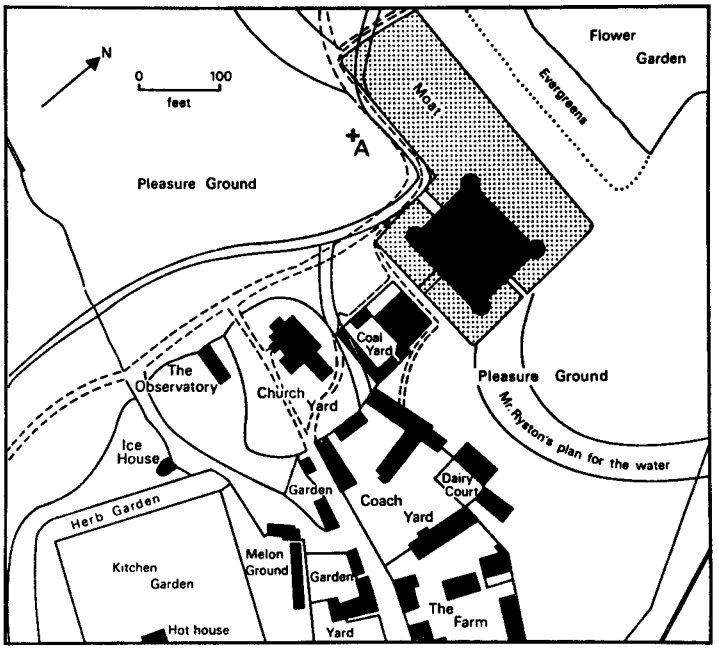

Figure 1. Portion of an estate plan of Shirburn Castle in the late 18th century, showing the site of the Observatory.

oversheltered by trees. Today the site is covered by a small clump of trees. Figure 1 reproduces a part of Davis's map showing the site of the Observatory in relation to other buildings on the estate.

2. The rainfall record

The record of rainfall is contained in two bound notebooks ruled for the purpose and it starts in the middle of September 1779 with a note which reads:

'Wednesday, 15th September 1779. Put up a new funnel for the ombrometer, of a foot diameter and circular, a large glass tube was adapted to the bottom of the pipe for a receiver of the rain, graduated so as to divide one inch of rain into 100 parts. The tube holds $1\frac{2}{10}$ of an inch. N.B. The Observations are supposed to be taken at noon of each day marked against them, unless otherwise—in the remarks.'

The reference to a 'new funnel' in this note suggests that an earlier rain-gauge had existed. The meteorological entries in the earlier astronomical journals make no reference to actual measured quantities of rain, but there is a slip of loose paper in one of them (Savile MS. 77) which reads: 'water fallen in October 1778 and to November 27th at noon October: 3.10156 inches

November: 3.796875 inches'.

This suggests that earlier attempts to measure rainfall had been made; while the monthly totals to five and six decimal places would suggest that this had been done by the weight of water collected, following the method used by Dr Thomas Hornsby from his early measurements at Oxford (Craddock and Craddock, 1977).

The introduction of a new funnel of one foot diameter in September 1779 and the use of a graduated glass measuring cylinder also suggest collaboration with Hornsby who, like his predecessor Bradley, was a frequent visitor at Shirburn. Both Hornsby's own meteorological journal and the Shirburn astronomical journals make occasional reference to Hornsby's visits to the Castle and it seems that

the Shirburn observers often sought Hornsby's advice. It is therefore a reasonable inference that the 'new funnel' for the Shirburn gauge may have been similar to one of the same dimensions purchased by Hornsby from P. and J. Dolland in 1774 (Gunther, 1923) for use at the Radcliffe Observatory. The fact that Hornsby's own rainfall record at Oxford apparently ceased from September 1776 until renewed again in 1785, presumably because of the building work at the Radcliffe Observatory (Craddock and Craddock, 1977) may have encouraged Hornsby to urge that a rainfall record be maintained at Shirburn. The Shirburn journals make no reference to the actual site or elevation of the gauge but, as is discussed below, there is good reason to believe that it was comparable to a modern standard exposure.

The manuscript record is neatly maintained and written and, during the earlier years, the measuring cylinder was read daily. The vessel was emptied only when a substantial amount of water had accumulated and the amount emptied was then noted in the journal. Although there is no record that the vessel ever filled and overflowed during heavy rain, so that some of the catch was lost, this possibility cannot be entirely discounted; maybe the observers were always alert to this danger and read the gauge before it overflowed? After 1787 readings became less frequent until, from 1791 onwards, the gauge appears to have been read only after significant falls of rain. However, the gauge was read on the last day of each month right up until April 1795, after which the entries become even fewer and the writing suggests a rapid deterioration in the observer's physical powers through age or infirmity. The monthly totals entered in the journal have been checked against the daily entries and in only a few cases was a discrepancy found; these were mostly small and could be attributed to an error of addition or to an illegible figure.

3. The identity of the observers

The journal contains no clues to the identity of the observers. The third Earl, Thomas Parker, died in February 1795 and there is nothing to suggest that he personally maintained the record which ceases with the last entry in October of that year. The rainfall record must have been maintained for most of the period described here by some servant in the Earl's employment who succeeded Phelps and Bartlett, the two astronomical observers trained by George Parker, the second Earl. Although George Parker at first made most of the astronomical observations personally, various descriptions exist of how he trained two of his servants, Thomas Phelps (1694–1777 or 1778) and John Bartlett (1722–83), to assist him. There is a contemporary engraving of these two men in the act of taking an observation; it is dated 1776 and is in the possession of the Royal Astronomical Society. There is an undated memorial tablet to Phelps in the vestry of Shirburn church which records that he died in his 84th year and praises his mathematical skill, 'acquired by his own industry'. The tablet refers to his having 'for many years the Management of the Observatory belonging to the Earl of Macclesfield'. Phelps was originally a stable boy and Bartlett a shepherd in the Earl's employment, but both were clearly men of parts who, either through schooling or training, were both literate and numerate (Dictionary of National Biography and Mary Frances, Countess of Macclesfield). Phelps was dead by the time the surviving rainfall record started, but Bartlett may have been concerned with it, for an entry in the journal for 19 October 1783 reads 'John Bartlett died this day'. This is the only fact other than rainfall measurement entered in the two volumes discussed here.

4. The relationship between Hornsby's Oxford rainfall record and that at Shirburn Castle

The monthly and annual totals of rainfall recorded at Shirburn between October 1779 and October 1795 are set out in Table I. Table II sets out the monthly and annual mean values for Shirburn during

Table I. *Monthly and annual rainfall at Shirburn between October 1779 and October 1795*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total for year
							inches						
1779										2·76	2·06	4·67	
1780	1·12	0·63	1·11	2·19	1·37	1·44	2·08	1·19	2·92	2·86	2·40	0·07	19·38
1781	1·66	1·75	0·08	1·14	1·56	3·36	1·78	1·39	2·67	0·32	2·95	1·87	20·53
1782	2·07	0·62	2·73	2·56	3·77	1·35	5·13	4·38	2·51	1·18	1·46	0·74	28·50
1783	1·59	3·16	1·33	0·57	2·35	2·70	2·33	2·05	2·74	0·64	1·56	0·94	21·96
1784	1·60	0·65	1·97	3·23	2·30	2·45	2·51	2·40	2·00	0·34	2·73	1·80	23·98
1785	1·62	1·02	0·25	0·28	0·76	1·61	1·40	2·33	4·63	2·54	1·89	1·91	20·24
1786	2·85	0·59	1·21	0·82	2·31	1·21	0·49	1·66	2·99	3·83	2·12	2·10	22·18
1787	0·32	1·96	2·75	0·87	1·60	1·13	5·65	1·17	1·49	2·57	1·56	2·81	23·88
1788	0·79	2·58	0·91	0·50	0·48	2·78	0·92	4·00	2·38	0·20	0·59	0·37	16·50
1789	2·46	1·90	1·69	1·24	2·43	4·66	4·13	1·19	2·89	3·48	1·43	1·53	29·03
1790	1·48	0·20	0·43	2·02	2·87	1·24	2·36	2·35	0·70	0·65	3·73	2·69	20·72
1791	3·17	1·52	0·80	1·48	0·91	0·59	2·76	1·42	0·70	3·15	4·45	2·15	23·10
1792	3·23*	0·57	1·92	3·20	2·06	2·95	3·15	3·52	4·00	3·83	0·93	1·48	30·84
1793	2·42	1·28	1·73	2·04	1·82	0·65	2·52	1·70	4·61	0·97	1·80	1·98	23·52
1794	0·53	1·06	1·36	2·20	2·23	0·65	2·84	1·98	2·86	3·33	5·09	2·19	26·32
1795	0·66	1·93	2·55	1·05	0·68	1·73	2·06	1·44	0·53	4·12			

* Reading could be 2·73. Underlined values are doubtful.

Table II. *Comparison of Shirburn and Oxford rainfall in the 18th century*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
							inches						
(a) Shirburn 1780–94	1·79	1·30	1·35	1·62	1·92	1·92	2·67	2·18	2·67	1·99	2·31	1·64	23·38
(b) Shirburn 1785–94	1·89	1·27	1·31	1·47	1·75	1·75	2·62	2·13	2·73	2·45	2·36	1·92	23·63
(c) Oxford (Hornsby) 1785–94	1·86	1·21	1·22	1·41	1·70	1·69	2·53	2·00	2·61	2·42	2·28	1·87	22·81
							per cent						
c) as a percentage of (b)	98·4	95·3	93·1	95·9	97·1	96·6	96·6	93·9	95·6	98·8	96·6	97·4	96·5

the 15 year period 1780–94 and the 10 year period 1785–94 during which there is available Hornsby's rainfall record for Oxford. In the same table Hornsby's values for Oxford are set out corrected by the Knox-Shaw and Balk conversion factor used by Craddock and Craddock (1977) and Craddock and Smith (1978) in their examination and homogenization of the Oxford rainfall record. From a comparison of the Oxford and Shirburn annual values the factor required to convert the Shirburn values to those of Oxford works out at 0.965; this is slightly smaller than the value found by Craddock and Craddock (1977) but the difference can be accounted for by some doubtful and revised figures in the Shirburn manuscript and a doubtful value given by the Craddocks for the annual rainfall at Oxford in 1792.

5. The relationship between a modern record at Shirburn and that at Oxford

It so happens that a modern rainfall record exists at two separate but closely adjacent sites at Shirburn from 1965 onwards. This record appears in *British Rainfall* as Shirburn Castle and in the *Monthly Weather Report* as Shirburn (Model Farm) and has been maintained by members of the Parker family who still reside at Shirburn. From 1965 until the end of 1967 a rain-gauge was sited on the lawn to the west of the Castle (shown at Point A on Figure 1), which is about 90 m north of

the site of the Observatory. Since 1 January 1968 the record has been continued with a gauge sited at Shirburn Model Farm, situated 1100 m north of the Castle, at virtually the same altitude. This modern Shirburn record is compared with the present Oxford record at the Radcliffe Meteorological Station in Table III. From this comparison it appears that a conversion factor of 0·967 is required to bring the Shirburn values to those of Oxford during the 10 year period 1965–74. Since the Oxford values for the modern and the 18th century decades form part of a homogeneous record and those from Shirburn are from virtually identical sites, assuming that the exposure of the gauges is approximately the same, this agreement is to be expected but it is most reassuring that the conversion factors for the two periods are so nearly identical. The conversion factor for the 13 year period 1965–77 is 0·966.

Table III. *Oxford (Radcliffe meteorological station) and Shirburn annual rainfall compared during the period 1965–77*

Year	Oxford (Radcliffe)	Shirburn		Oxford as a percentage of Shirburn
	inches	*inches*		
1965	25·87	28·23	(a)	91·6
1966	29·53	32·09		92·0
1967	27·52	30·51		90·2
1968	31·97	30·94	(b)	103·3
1969	23·94	21·97		109·0
1970	25·20	28·07		89·8
1971	29·17	26·42		110·4
1972	22·68	23·86		95·1
1973	19·49	21·10		92·4
1974	30·87	32·24		95·8
1975	21·18	20·79		101·9
1976	20·04	21·30		94·1
1977	27·95	29·61		94·4
Mean for 10 years 1965–74	26·62	27·54		96·7
Mean for 13 years 1965–77	25·80	26·70		96·6
Mean for 10 years 1968–77	25·25	25·63		98·5

(a) Castle (b) Model Farm

The annual variations of the difference Shirburn minus Oxford during the earlier and recent periods are shown graphically in Figure 2. As is to be expected at two sites separated by this distance there is some variation from year to year, reflecting different local rainfall events, but the interannual fluctuations are of the same order of magnitude. Further confirmation that the relationship between the rainfall at Shirburn and that at Oxford is of the right order can be obtained from the existence of another rainfall record close by with a continuous record reported in *British Rainfall* since 1886. This is at Pyrton Manor (National Grid Reference SU 686956, altitude 99 m) situated 1100 m west of Shirburn Castle. The factor required to convert the mean annual rainfall at Pyrton to that of Oxford over the period 1916–50 is 0·952 and for the earlier period 1881–1915 the factor is 0·936.

Rainfall readings were maintained intermittently at Shirburn Castle between 1894 and 1964 but only some parts of the record have been found. According to the Earl of Macclesfield (personal communication) the gauge was probably located in the kitchen garden near the site of the old Observatory. The annual totals of this gauge for 1894 and 1895 appear in *British Rainfall* for those

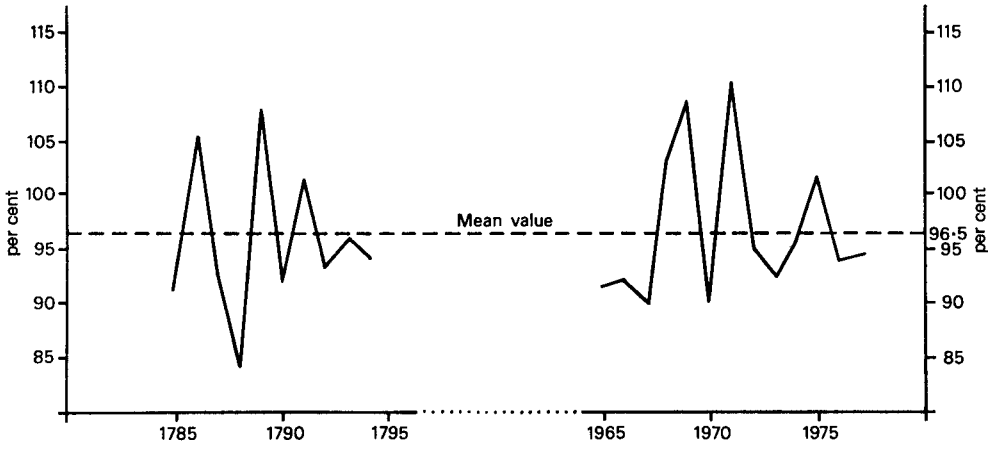

Figure 2. Annual differences of rainfall, Oxford as a percentage of Shirburn, in the 18th and 20th centuries.

years but subsequent daily readings, up to and including November 1909, were found in a notebook at Shirburn Castle. The internal evidence of this record suggests that some of the readings may not be very reliable. The author has checked these readings and recalculated monthly and annual totals to correct some arithmetical errors. The annual mean for Shirburn over the 15 year period 1894–1908 works out at 26·64 inches compared with means of 26·09 inches for Pyrton Manor and 23·86 inches for Oxford (Radcliffe) over the same years. The Oxford mean is thus only 89·6 per cent that of Shirburn and 91·4 per cent that of Pyrton for this period. It would appear from this and other evidence that the Pyrton readings are more representative and the Shirburn record is defective at this time.

6. Discussion and conclusion

Although it only covers a short period of 15 years the 18th century Shirburn Castle record is extremely valuable in confirming some doubtful points about the early rainfall record of Hornsby at the Radcliffe Observatory, Oxford. The remarkable agreement between the records at Shirburn and Oxford during two different periods in the 18th and 20th centuries suggests that the early Shirburn record is from a well-exposed gauge and allows it to be compared with modern records.

The histograms at Figure 3 show the monthly distribution of rainfall at Shirburn over the two periods, 1780–94 and 1785–94. They indicate that this was a time when the annual rainfall regime of the south Midlands was rather more continental, with drier winters and wetter summers, than has been the case during the present century. The regime resembles that noted by Smith (1974) as prevailing at Oxford between 1831 and 1900. There remains however the doubt, noted by Craddock and Smith (1978), concerning the problem of whether and how winter precipitation in the form of snow was measured. In an average year this could reduce the winter precipitation by as much as half an inch if snow was not measured. The annual rainfall totals and period mean for Shirburn in the 18th century also indicate that this was a time of rather low annual rainfall. However, the dryness of this period is within the range of fluctuation experienced at Oxford during the last two hundred years. The driest ten years in the Oxford rainfall record occurred between 1893 and 1902 with a 10 year mean of 22·16 inches. The 15 year mean for Shirburn between 1780 and 1794, when multiplied by the factor 0·965, is 22·56 inches and the 10 year mean 1785–94, when similarly reduced to the equivalent value for Oxford, is 22·80 inches.

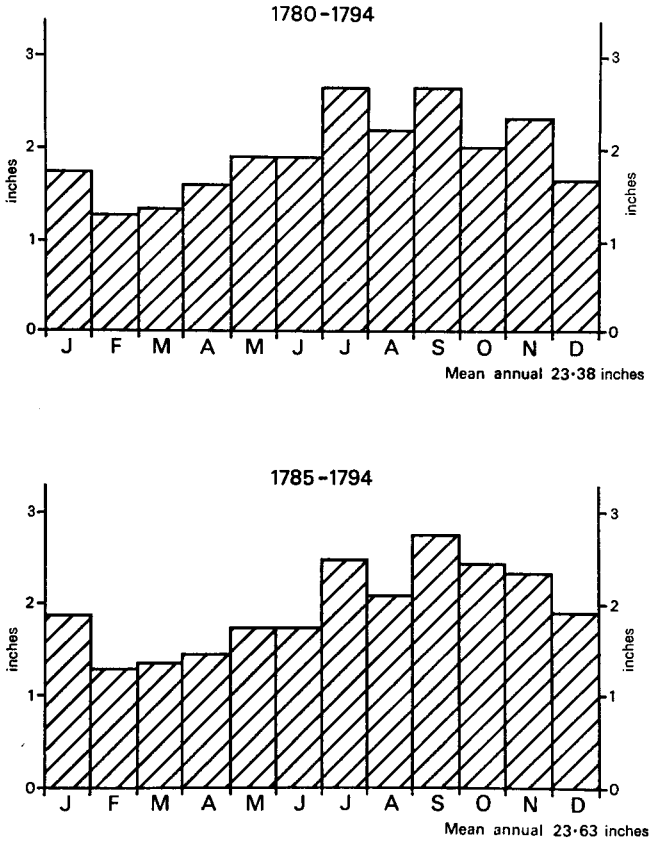

Figure 3. The mean monthly distribution of the annual rainfall at Shirburn in the 18th century.

Acknowledgements

I am indebted to Professor Gordon Manley for drawing my attention to the existence of the 18th century Shirburn rainfall record and to the Earl of Macclesfield and the Honourable David Parker for allowing me access and for discussion of the history of the site. Mr J. M. Craddock has encouraged me to pursue this matter and so add a long footnote to his own work on early British rainfall records.

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Smith, C. G.	1968	The Radcliffe Meteorological Station. *Weather*, **23**, 362–367.
	1974	Monthly, seasonal and annual fluctuations of rainfall at Oxford since 1815. *Weather*, **29**, 1–16.

Notes and news

The World Climate Conference, 12–23 February 1979

It was announced some time ago that the World Meteorological Organization (WMO), in collaboration with other organizations (the Food and Agriculture Organization, Unesco, the World Health Organization, the United Nations Environment Program, the International Council of Scientific Unions, and the International Institute for Applied Systems Analysis) was to convene the World Climate Conference (WCC)—A Conference of Experts on Climate and Mankind. The Conference is being held in Geneva, Switzerland, from 12 to 23 February 1979.

Mr M. F. Taha, the President of WMO, has been designated by the WMO Executive Committee as the Honorary President of the Conference and Dr Robert M. White of the United States National Academy of Sciences has been appointed Chairman.

The Conference was originally conceived as a scientific preliminary to the convening of a high-level (Ministerial-level) conference at which the need to take climatic factors into account in taking decisions in the economic and social fields would be stressed. It is now expected that the Conference will provide useful proposals for the plan for a World Climate Program which will be considered and, it is hoped, approved by the Eighth World Meteorological Congress to be held in April/May 1979.

The Conference will be at the expert level, and attendance will be by invitation. During the first week of the Conference 24 review papers will be presented and discussed, before about 400 invited participants. (One such review paper, on the results of climate models, will be presented by the Director-General of the Meteorological Office, Dr B. J. Mason.) The second week will be devoted to the formulation of a plan of action, including arrangements for a subsequent high-level conference and proposals for the World Climate Program.

The object of the Conference is to examine the impact of climate, and especially of climatic fluctuations on all time scales, on various aspects of human welfare. In recent years there have been many severe impacts of climate on food production, on energy supply and consumption, on high-latitude marine navigation and on many other aspects of the world economy. The Conference will examine these impacts, and will consider measures to reduce climate-induced crop and livestock losses, damage to soil and natural vegetation, dislocation of fisheries, and of the future exploitation of other marine sources.

In addition, the Conference will address the broader questions: 'How can human economy be better attuned to the probable future course of world climate? Will, for example, expanded use of fossil fuels lead to climatic change through the build-up of carbon dioxide in the atmosphere? Will other pollutants have similar or different effects? Are the effects likely to be good or bad, and who will gain or lose? And what measures can be advocated to avoid the bad outcomes, and to take advantage of the good?'

Participants in the Conference will include many leading atmospheric scientists, but most of the invited experts will be drawn from other sciences or the socio-economic field so that these far-reaching questions may be searchingly discussed.

(Adapted from a WMO Press Release.)

Awards

Awards to the Director-General

We note with great pleasure the following awards to the Director-General of the Meteorological Office, Dr B. J. Mason, C.B., F.R.S.

The London Mathematical Society has awarded Dr Mason its Naylor Prize and Lectureship for distinguished contributions to the application of mathematics. Dr Mason is the second recipient of the Prize, the first having been Sir James Lighthill.

The Queen's University of Belfast has elected Dr Mason to the Sir Joseph Larmor Lectureship for 1979.

Obituary

We regret to record the death on 8 October 1978 of Miss Patricia Lutt, re-employed Assistant Scientific Officer. Miss Lutt joined the Office in May 1941 and spent most of the early part of her career at Dunstable. In September 1950 she was posted to London Airport at Heathrow and remained there—apart from occasional temporary postings—until she retired in April 1977 as a Senior Scientific Officer. At Heathrow she became widely known for her participation in the social life of the Office—serving on committees, working behind the scenes in various ways, writing a monthly news-letter, conducting a widespread correspondence with many past members of the staff, and keeping a friendly eye on the interests of juniors and new entrants. She performed many acts of kindness and practical helpfulness for her colleagues and friends. In recognition of her services to the social life of the Meteorological Office she was awarded the Sutton Rosebowl in 1971. At the time of her death she was employed in the observational practices branch (Met O 1).

THE METEOROLOGICAL MAGAZINE

No. 1279 February 1979 Vol. 108

CONTENTS

Page

The Royal Meteorological Society Exhibition 1978 33

Visit of Her Majesty The Queen to the Meteorological Office, 14 July 1978 34

Concerning general circulation models. A Gilchrist.. 35

An eighteenth century rainfall record at Shirburn Castle, Oxfordshire. C. G. Smith 52

Notes and news

The World Climate Conference, 12–23 February 1979 59

Awards

Awards to the Director-General 60

Obituary 60

NOTICES

It is requested that all books for review and communications for the Editor be addressed to the Director-General, Meteorological Office, London Road, Bracknell Berkshire RG12 2SZ, and marked 'For Meteorological Magazine'.

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